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ABSTRACT

A project was conducted to develop a curriculum and training materials to be used in training industrial operatives in statistical process control (SPC) techniques. During the first phase of the project, questionnaires were sent to 685 companies (215 of which responded) to determine where SPC was being used, what type of SPC firms needed, and how such training should be organized and delivered. Next, one-day site visits were made to a series of the responding firms to collect case study materials and identify the problems entailed in introducing SPC into an organization. The information that had been gathered from the questionnaires and the site visits was then used as the basis for developing the following project products: a trainer's guide, a trainee's manual, case studies covering some 20 organizations, various SPC training aids, and a project report. All of the training materials were then field-tested at several organizations. Although some difficulties arose because of the logistics of providing the material in time to match company training requirements, feedback on the materials was positive and indicated that their format, approach, and content level all met trainees' needs. (An appendix contains 14 points developed by W. Edwards Deming, a colleague of Walter Shewhart, who was the founder of modern statistical control methods.) (MN)

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STATISTICAL PROCESS CONTROL

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FEU / PICKUP

PROJECT REPORT

STATISTICAL PROCESS CONTROL

A summary

Project Director: M Owen

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Training for Quality Unit
Bristol Polytechnic

Further Education Unit

Professional, Industrial and Commercial Updating

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FOREWORD

The authors of this summary report believe that industrial success is dependent on the adoption of appropriate quality assurance procedures. The report suggests that such procedures should be based on the application of problem-solving and statistical process control techniques similar to those that have been influential in the success of Japanese industry, and notes that many of the larger companies in the western nations have begun to introduce such methods of quality assurance.

The full report* describes how Mal Owen and Ian Clark of the Training for Quality Unit (TQU) at Bristol Polytechnic carried out a needs analysis exercise and developed a significant package of training materials for use by educational and industrial institutions for the training of management and operational staff in industry. It also highlights the fact that statistical process control techniques are not limited to manufacturing industries, but can be applied in any situation where statistical data is available for analysis.

The materials produced by TQU include a *Trainers' Guide*, a *Training Manual*, a book of case studies, and a complete set of materials to perform experiments described in the text. The complete pack is supplied in a convenient case. Further details are available from the TQU**. Samples of the materials may be inspected at any FEU Local Information Centre***.

The report and associated materials should be of interest to all concerned with the development and implementation of training opportunities aimed at updating industrial personnel in the theory and practice of statistical process control.

FEU would welcome comments on the report and the TQU materials, or suggestions for further areas of curriculum development work in the quality assurance field. Enquiries, comments and suggestions should be addressed to Albert Clyde at FEU (tel: 01-321-0433).

Dennis Drysdale
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1. INTRODUCTION

The success of Japan as a trading nation is largely due to its ability to produce goods of consistently high quality. A commitment to training has been a key element in this drive for continuous improvement in quality. Training in problem-solving techniques and simple statistical methods, which have subsequently been adopted in company-wide programmes, has been particularly effective.

The development of these techniques followed a series of visits to Japan, in the late 1940s, by the American consultant Dr W Edwards Deming. Deming had been a colleague of Walter Shewhart, the founder of modern statistical control methods. The Japanese listened to his message on understanding variability and the need to change management style and, as a result, large-scale training programmes were undertaken in Japan. Some 30 years after his presentations in Japan, his views were taken up by large organisations in the USA, particularly those in the automobile industry, such as Ford and General Motors.

The message has come through to Britain and, since 1984, the Ford Motor Company has been actively promoting the introduction of Statistical Process Control (SPC) in its supply base. In effect, Ford has insisted that all its suppliers must use SPC programmes.

Ford discovered a dearth of practical training in statistical methods and introduced company training programmes to cover the updating needs of the workforce, from senior executive to operator/clerk. However, the largest group in need of training will be the shop-floor operators.

To meet the needs of such industrial employees, this project was initiated by the Training for Quality Unit (TQU) at Bristol Polytechnic, under the direction of Mal Owen, with Ian Clark as Research Assistant.

2. AIMS OF THE PROJECT

The general aim of the project was to provide a potential resource to be used in the training of industrial operatives in SPC techniques.

The specific aims were:

- to produce the following resources:

  — a trainer's guide,
  — a trainee's manual,
  — case studies covering some 20 organisations,
  — a variety of SPC training aids,
  — a report on the project;

- to influence educational establishments to modify statistical/quality-related syllabuses to bring them into line with the needs of industry;

- to complement other initiatives in quality control/assurance;

- to set up agencies to provide supportive training and act as distribution centres for the SPC materials.

3. METHODOLOGY

The project was covered in six phases:

- Phase 1 — initial research whereby the SPC training needs of companies were determined;
- Phase 2 — the preparation of a research report;
- Phase 3 — visits to organisations to collect case study materials and identify the problems of introducing SPC into an organisation (see Section 5 of this summary report);
- Phase 4 — preparation and continuous refinement of the various training manuals and support materials;
- Phase 5 — field testing of the materials;
- Phase 6 — preparation of the final report and collation of materials.

This document reports on the methodological research aspects of the project. A separate paper, included as part of the training package, describes some of the problems and difficulties associated with the introduction of an SPC programme, as illustrated by a range of case studies.

4. THE RESEARCH

The first phase of the research consisted of a literature search to identify previous analyses in the area, together with related materials, books and articles. This assisted in the design of a questionnaire, and appropriate items were used in the preparation of training materials at a later stage of the project.

The sample

The questionnaire was designed to help estimate:

- techniques that were used in quality assurance;
- areas where SPC was used within the firm;
- aids that were considered suitable to assist SPC training;
- how, in the opinion of companies, training should be organised.

Questionnaires were sent to a total of 685 companies, some 515 of which had previously expressed an interest in quality assurance issues by borrowing a video from the Training for Quality Unit (TQU) at Bristol Polytechnic. The other companies were selected from industrial directories related to areas where the use of SPC techniques was considered to be appropriate. Table 1 gives a breakdown of the sample and the respondents in terms of broad industrial sectors.

It was recognised that this sample might not provide a complete picture of the use of SPC techniques in industry. However, by concentrating mainly on companies that had shown interest in SPC, the survey was likely to give a realistic idea of the SPC training required by industry.

TABLE 1: Breakdown of sample and respondents by industrial sectors.

Industrial sector	*No. in sample*	*Respondents:* 215		
		Using SPC	*Planning use of SPC*	*Not using SPC*
Utilities	2	0	0	2
Manufacturing	387	84	29	52
Construction	7	0	0	3
Services and public sector	289	2	0	43
TOTAL	685	86	29	100

Two hundred and fifteen companies (31% of the sample) responded to the questionnaire, of which 165 (77% of respondents) were engaged in manufacture. Of the 86 (40% of respondents) which claimed to be currently using SPC, all bar one were engineering companies.

QA techniques in use

This information was required so that SPC training manuals could be related to the techniques that the companies used or planned to implement. Techniques in use (or planned) included quality circles, statistical product control and production to BS 5750 requirements.

Areas where SPC was used within the company

Table 2 shows that most companies consider SPC to be a quality assurance technique that is mainly applicable in production departments rather than as part of a company-wide assurance system.

Table 2 Use of SPC by company departmental function

Function	*Frequency (%)*
Production	98
Accounts	9
Distribution/Storage	17
Personnel	5
Marketing	6
R&D	22
All operations	2

Aids for SPC training

The preferred training aid among the respondents was a training manual. Table 3 shows the frequency of this and other training aids.

Table 3 Training aids preferred

Aid	*Frequency (%)*
Training manual	68
OHP slides	52
Software	23
Video	58

Method of organisation of training

Table 4 shows the location and source of training in quality assurance techniques undertaken by respondents to the questionnaire. Table 5 shows the length of training given to various grades of staff. Together, these tables show that a substantial number of companies which claim to use SPC techniques have introduced the technique without any provision for staff training. Where training was provided, there were few cases where it exceeded three days. Most training was in-house, presumably because this was seen as being least expensive, and permitted on-the-job training. However, not all the companies which used in-house location had employees who could deliver training, and so used consultants or FHE staff.

Table 4 Location and source of training in QA techniques (1% of respondents who claimed to use SPC)

Employee	*Location*			*Source*			*Total % trained*
	In-house	*FHE college*	*Other*	*Own staff*	*FHE staff*	*Other*	
Senior managers	49	3	14	27	9	28	66
Middle managers	54	5	15	34	11	29	74
Quality managers	48	11	14	33	16	24	73
Supervisors	72	3	11	58	6	22	86
Technical staff	70	8	8	52	10	22	86
Operatives	70	0	0	59	1	10	70
Others	31	0	0	27	1	3	31

Table 5 Length of training in QA techniques

Employee grade	*% receiving more than 3 days training (in companies claiming to use SPC)*
Senior managers	17
Middle managers	21
Quality managers	27
Supervisors	21
Technical staff	24
Operatives	18
Others	6

5. COLLECTION OF CASE STUDY MATERIALS

The TQU had contacts with many industrial organisations, primarily through involvement with the DTI's National Quality Campaign, its links with the Ford Motor Company and other companies which had been established over many years. Twenty companies were approached with an initial request for co-operation in the project. This would involve a one-day visit to the company to view processes and talk to relevant staff, and the provision by the company of appropriate control charts and data which would form the basis of the case studies.

The response enabled sufficient material to be collected to provide case studies spanning a range of organisations — from multinationals to small companies, with products ranging from cars to coffee. These case studies form part of the training package and, while they can be used in a variety of ways, are mainly intended to be background material for the trainer.

6. PREPARATION OF TRAINING MATERIALS

A curriculum for training in SPC techniques was drawn up, based upon the information collected during the company interviews and upon the general experience of TQU staff. Much relevant training material was available, often in formal textbooks or as articles in technical journals, and this was collated and amended as necessary to produce a common format. Appropriate linking commentary and explanatory materials were prepared, together with sets of worked examples and practice exercises to be included in the trainees' manual. A set of experimental equipment was developed to permit trainees to undertake practical work in statistical processes. Additional material was prepared for inclusion in the trainers' guide which consisted of the trainees' manual and supplementary sheets overprinted with solutions to the exercises, together with guidance and instructions to the trainer. Some 130 OHP slides were prepared, mainly consisting of diagrams from the trainees' manual. Finally, the physical structure of the pack was designed and the various production processes set in motion.

The trainer guide and 12 copies of the trainee manual are provided with each training package. The OHP slides are provided in ring binders.

7. FIELD TESTING OF MATERIALS

As the materials were developed, they were field tested in several organisations. In practice, some difficulties arose, primarily due to the logistics of providing the material in time to match the company's own training requirements. Nevertheless, feedback was positive and indicated that the format of the material, its approach and content level were satisfying the needs of the trainees. The material was also supplied to other SPC contacts for comment.

8. CONCLUSIONS

The needs analysis confirmed that British industry needed updating in simple statistical/problem-solving techniques in order to compete effectively with overseas competition.

- Much more commitment is needed from senior management for the full potential of SPC to be realised. This should be a matter of priority and may be assisted by the development of learning materials aimed specifically at the higher echelons of management (e.g.by showing examples of SPC projects drawn from their own work spheres).
- More work needs to be done to promote SPC in the service sector to show that applications of the technique in this sector are cost effective. It would be useful to conduct further research in order to:
  - identify firms using SPC for quality assurance in functions other than production;
  - evaluate the effectiveness of the technique in this context;
  - develop, as necessary, suitable training materials for service sector applications.
- In order to promote a more collaborative approach to training for SPC, it is necessary to bring together managers, trade unionists, academics and consultants from a range of companies. This would help people to see that the problems they face are not specific to them but apply to other organisations as well, and would bring different perspectives to bear which would help in developing a fuller understanding of the technique.
- The evidence collected suggests a preference for short training courses in SPC, to be run either in-house or in institutions of further and higher education. While such programmes may successfully cover the rudiments of the technique, it is doubtful whether its full potential can be assimilated within such tight schedules. Therefore, there will be a need for refresher courses of training; curriculum development is required to ensure that up-dated techniques are being applied. In addition, it is essential that senior and middle managers are trained first so that they are more likely to understand the usefulness of SPC and become committed to it.
- The most popular training process is use of a training manual; 68% of our respondents used this method.
- Lack of knowledge of statistics was perceived to be a common pr blem in the context of SPC training. For this reason, learning materials should include an introduction to essential techniques.
- SPC is generally seen as a 'quality assurance' technique with relevance not extending beyond engineering applications. In fact, SPC has much wider implications and staff in all departments, and in many levels, may be able to apply SPC or other problem-solving tools. The value of SPC in solving a wide range of everyday problems needs particular emphasis.

9. RECOMMENDATIONS

- Further research into the development of SPC within non-manufacturing industry should be considered.

- Further/higher education syllabuses which do, or should, include aspects of SPC should clearly relate the potential of SPC in a wide range of current industrial needs and problems. In particular, management courses should emphasise the importance of quality and SPC as a means of achieving it.

- The education sector should accept the principles of SPC and use it to monitor and improve its own performance.

APPENDIX: DEMING'S FOURTEEN POINTS

The Deming philosophy of quality expresses a commitment to *total* quality control — quality is everyone's responsibility, be they manager, machine operator or clerk.

Deming's 14 points are suggested for adoption by management in order to effect continuous improvement and total quality assurance. They are:

- Innovate and allocate resources to fulfil the long-term needs of the organisation and the company rather than short-term profitability. Plan to become competitive and stay in business.

- Discard the old philosophy of accepting defective products. We can no longer live with commonly accepted levels of delays, mistakes, defective materials, poor production skills or bad service.

- Eliminate the dependence on mass inspection; instead use statistical evidence that quality is being built in.

- End the practice of awarding business on the basis of price alone. Price has no meaning unless considered alongside quality. Eliminate suppliers who cannot provide statistical evidence of quality of performance.

- Use statistical techniques to solve problems and identify waste. It is management's job to work continually on the system (design, incoming materials, composition of materials, maintenance, machine improvement, training and supervision) so that the level of waste can be minimised.

- Institute more thorough, job-related training.

- Provide modern methods of supervision of production workers. Management must respond to reports from supervisors concerning inherent defects, machines not maintained, poor tooling, unclear operational definitions, etc.

- Reduce fear throughout the organisation by encouraging open two-way communications. Questions should be asked, suggestions made and trouble reported as soon aspossible, and action taken by management.

- Break down barriers between departments. People in research, design, sales and production should work together to consider production problems that may occur with various materials and specifications.

- Eliminate the use of goals and slogans to encourage productivity.
- Eliminate work standards based on numerical quotas alone. They often act as an impediment to quality improvement.
- Remove barriers that stand between the hourly paid worker and the right to pride in the quality of one's work.
- Institute a vigorous programme of education and training in new skills in order to keep up with the changes in materials, methods, product designs and machinery.
- Create a structure in top management that will continually promote the previous 13 points.

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